

FAR and NEAR Target Dynamic Visual Acuity:
A Functional Assessment of Canal and Otolith Performance

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Background: Upon their return to earth, astronauts experience the effects of vestibular adaptation to microgravity. The postflight changes in vestibular information processing can affect postural and locomotor stability and may lead to oscillopsia during activities of daily living. However, it is likely that time spent in microgravity affects canal and otolith function differently. As a result, the isolated rotational stimuli used in traditional tests of canal function may fail to identify vestibular deficits after spaceflight. Also, the functional consequences of deficits that are identified often remain unknown.

In a gaze control task, the relative contributions of the canal and otolith organs are modulated with viewing distance. The ability to stabilize gaze during a perturbation, on visual targets placed at different distances from the head may therefore provide independent insight into the function of this systems.

Objective: Our goal was to develop a functional measure of gaze control that can also offer independent information about the function of the canal and otolith organs.

Methods: Dynamic Visual Acuity (DVA) was assessed for 10 subjects using both FAR (4m) and NEAR (0.5m) viewing distances. A custom-written acuity threshold determination program was used to display Landolt C optotypes on a laptop computer screen for the FAR condition and on a micro-display for the NEAR condition. Actively-generated perturbations were created by having the subjects walk (1.79 m/s) on a treadmill. The changes in acuity that are attributable to inadequate compensation for body movements were isolated by subtracting each subject's standing acuity from their walking acuity at each viewing distance.

Results: With a mean decrement of 0.26 logMAR (range: 0.16 to 0.36), the decrease in visual acuity between standing and walking was significantly greater ($p < 0.00001$) in the NEAR target condition when compared to the FAR condition (mean: 0.02, range: -0.02 to 0.1). This result is consistent with the subjective reports of relative target motion in the NEAR condition and provides quantitative evidence that gaze stabilization mechanisms do not fully compensate for the movements in the NEAR condition in normal subjects.

Conclusion: The locomotion paradigm described here provides a functionally-relevant measure of gaze control that may be useful for measuring readaptation in returning astronauts or recovery of patients with vestibular disorders. If the perturbations can be sufficiently isolated, DVA at different viewing distances may also be useful for investigating the differential effects of an intervention, (e.g. spaceflight) on the canal and otolith organs.